polymer films by inducing Bragg scattering of light that is guided laterally through the emissive layers; see "Modification of polymer light emission by lateral microstructure" by Safonov et al., Synthetic Metals 116, 2001, pp. 145-148, and "Bragg scattering from periodically microstructured light emitting diodes" by Lupton et al., Applied Physics Letters, Vol. 77, No. 21, Nov. 20, 2000, pp. 3340-3342. Brightness enhancement films having diffractive properties and surface and volume diffusers are described in WO0237568 A1 entitled "Brightness and Contrast Enhancement of Direct View Emissive Displays" by Chou et al., published May 10, 2002. The use of micro-cavity techniques is also known; for example, see "Sharply directed emission in organic electroluminescent diodes with an optical-microcavity structure" by Tsutsui et al., Applied Physics Letters 65, No. 15, Oct. 10, 1994, pp. 1868-1870. However, none of these approaches cause all, or nearly all, of the light produced to be emitted from the device. Moreover, such diffractive techniques cause a significant frequency dependence on the angle of emission so that the color of the light emitted from the device changes with the viewer's perspective.

[0009] Reflective structures surrounding a light-emitting area or pixel are referenced in U.S. Pat. No. 5,834,893 issued Nov. 10, 1998 to Bulovic et al. and describe the use of angled or slanted reflective walls at the edge of each pixel. Similarly, Forrest et al. describe pixels with slanted walls in U.S. Pat. No. 6,091,195 issued Jul. 18, 2000. These approaches use reflectors located at the edges of the light emitting areas. However, considerable light is still lost through absorption of the light as it travels laterally through the layers parallel to the substrate within a single pixel or light emitting area.

[0010] Scattering techniques are also known. Chou (International Publication Number WO 02/37580 A1) and Liu et al. (U.S. Patent Application Publication No. 2001/0026124 A1) taught the use of a volume or surface scattering layer to improve light extraction. The scattering layer is applied next to the organic layers or on the outside surface of the glass substrate and has optical index that matches these layers. Light emitted from the OLED device at higher than critical angle that would have otherwise been trapped can penetrate into the scattering layer and be scattered out of the device. The efficiency of the OLED device is thereby improved but still has deficiencies as explained below.

[0011] U.S. Pat. No. 6,787,796 entitled "Organic electroluminescent display device and method of manufacturing the same" by Do et al issued Sep. 7, 2004 describes an organic electroluminescent (EL) display device and a method of manufacturing the same. The organic EL device includes a substrate layer, a first electrode layer formed on the substrate layer, an organic layer formed on the first electrode layer, and a second electrode layer formed on the organic layer, wherein a light loss preventing layer having different refractive index areas is formed between layers of the organic EL device having a large difference in refractive index among the respective layers. U.S. Patent Application Publication No. 2004/0217702 entitled "Light extracting designs for organic light emitting diodes" by Garner et al., similarly discloses use of microstructures to provide internal refractive index variations or internal or surface physical variations that function to perturb the propagation of internal waveguide modes within an OLED. When employed in a top-emitter embodiment, the use of an index-matched polymer adjacent the encapsulating cover is disclosed.

[0012] However, scattering techniques, by themselves, cause light to pass through the light-absorbing material layers multiple times where they are absorbed and converted to heat. Moreover, trapped light may propagate a considerable distance horizontally through the cover, substrate, or organic layers before being scattered out of the device, thereby reducing the sharpness of the device in pixellated applications such as displays. For example, as illustrated in **FIG. 15**, a prior-art pixellated bottom-emitting OLED device may include a plurality of independently controlled pixels **30**, **32**, **34**, **36**, and **38** and a scattering layer **22** located between the transparent first electrode **12** and the substrate **10**. A light ray **5** emitted from the light-emitting layer may be scattered multiple times by scattering layer **22**, while traveling through the substrate **10**, organic layer(s) **14**, and transparent first electrode **12** before it is emitted from the device. When the light ray **5** is finally emitted from the device, the light ray **5** has traveled a considerable distance through the various device layers from the original pixel **30** location where it originated to a remote pixel **38** where it is emitted, thus reducing sharpness. Most of the lateral travel occurs in the substrate **10**, because that is by far the thickest layer in the package. Also, the amount of light emitted is reduced due to absorption of light in the various layers. If the light scattering layer is alternatively placed adjacent to a transparent encapsulating cover of a top-emitting device as illustrated in **FIG. 16**, the light may similarly travel a significant distance in the encapsulating cover **20** before being emitted.

[0013] Light-scattering layers used externally to an OLED device are described in U.S. Patent Application Publication No. 2005/0018431 entitled "Organic electroluminescent devices having improved light extraction" by Shiang and U.S. Pat. No. 5,955,837 entitled "System with an active layer of a medium having light-scattering properties for flat-panel display devices" by Horikx, et al. These disclosures describe and define properties of scattering layers located on a substrate in detail. Likewise, U.S. Pat. No. 6,777,871 entitled "Organic ElectroLuminescent Devices with Enhanced Light Extraction" by Duggal et al., describes the use of an output coupler comprising a composite layer having specific refractive indices and scattering properties. While useful for extracting light, this approach will only extract light that propagates in the substrate (illustrated with light ray **2**) and will not extract light that propagates through the organic layers and electrodes (illustrated with light ray **3**). Moreover, if applied to display devices, this structure will decrease the perceived sharpness of the display. Referring to **FIG. 17**, the sharpness of an active matrix OLED device employing a light-scattering layer coated on the substrate is illustrated. The average MTF (sharpness) of the device (in both horizontal and vertical directions) is plotted for an OLED device with the light-scattering layer and without the light scattering layer. As is shown, the device with the light-scattering layer is much less sharp than the device without the light scattering layer, although more light was extracted (not shown) from the OLED device with the light-scattering layer.

[0014] U.S. Patent Application Publication No. 2004/0061136 entitled "Organic light emitting device having enhanced light extraction efficiency" by Tyan et al., describes an enhanced light extraction OLED device that includes a light scattering layer. In certain embodiments, a low index isolation layer (having an optical index substan-